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Quarterly Progress Report, Mar 1991 – May 1991
ONR Contract Number N00014-91-J-1577
Drew McDermott, PI
Yale University Department of Computer Science

We spent the first three months of the project focusing on these activities:

1. Consolidation and publication of work from previous grants

2. Research on perception in mobile agents

3. Investment in laboratory infrastructure

Prof. Drew McDermott and Sean Engelson focused on developing a heuristic model of place perception for mobile robots. The model differs from past approaches in its emphasis on error correction. As a network of places is developed, the system keeps statistics that tell it when to merge two locations previously thought distinct, and when to split one supposed location into two.

Prof. Greg Hager has been working together with Sami Atiya of Karlsruhe University to extend their work in robot localization. The latest version of their algorithm includes techniques for models of robot motion and map learning. The work is largely finished and has been submitted to be published in the IEEE Journal of Robotics and Automation.

Hager's work in interval-based model recovery and decision-making has been reimplemented in C++. The new implementation includes all of the results from his previous work, and includes several extensions. In particular, the new system can solve general systems of nonlinear equations in a very natural and clean fashion.

Prof. McDermott also spent time designing and implementing the interface between the reactive interpreter and plan layer for the XFRM planner. The interpreter can now report failures to the planner, which then attempts to rethink the plan. It can also make changes dynamically in response to changing orders. Planning runs in parallel with plan execution, and when an improved plan is found, the old one is replaced by the new one. This flexible architecture allows plans to continue controlling a robot even after parts of them have failed, provided the remaining parts make sense.

Activities:
Prof. Hager attended the IEEE Conference on Robotics and Automation.
Prof. McDermott gave a talk in March at MIT on the topic "Planning Reactive Behavior."

Publications:

1 Atiya, S. and G. D. Hager, Real-time vision-based robot localization. In *Proceedings of the 1991 IEEE International Conference on Robotics and Automation*, pages 639–643. IEEE Computer Society Press.

2 Hager, G. D. and M. Mintz, Computational methods for task-directed sensor data fusion and sensor planning. *The International Journal of Robotics Research*, 10(4).

Man-Hours:
Several people worked full-time (except for teaching duties) on this project: Michael Beetz (graduate student), Sean Engelson (graduate student), Greg Hager (Assistant Professor), and Drew McDermott (Professor). However, during the period covered by this report, all of their salaries were covered by fellowships or by Yale University sources.

91-11798

UNIVERSITY GENERAL LEDGER DESCRIPTION	AMOUNT BUDGETED	COMMITTED (NOT PAID)	PAID TO DATE	TOTAL EXPENSES	REMAINING BALANCE
FACULTY SUMMER COMP	16,050	11,555	5,555	17,111	-1,061
CLERICAL & TECHNICAL	8,000	8,300	636	8,935.97	-935.97
STUDENT ASST. IN RESEARCH	42,900	3,600	0	3,600.00	39,300.00
DIRECT WAGES	0	0	344	344	-344
ASSESSMENTS: EMPL. BENEFITS	8,491	6,254	1,861	8,115	375
DATA PROC. SUPPLIES	0	404	1,327.35	1,731	-1,731.35
DATA PROC. SVS.	12,000	0	0	0	12,000.00
D/P SOFTWARE PURCHASES	0	1,440	988	2,428	-2,428
FREIGHT & TRANSPORTATION	0	0	13	13	-13
PHOTOCOPY SERVICES	2,000	0	0	0	2,000
TRAVEL-DOMESTIC	4,000	0	123	123	3,877
OFFICE SUPPLIES	1,000	-99	215	116	884
PERIODICALS, BOOKS	0	0	51	51	-51
TUITION REMISSION	21,513	0	0	0	21,513
TELEPHONE RATED TOLLS	1,000	0	0	0	1,000
DATA PROC. EQUIPMENT	83,000	3,780	10,690	14,470	68,530
INDIRECT (OVERHEAD 68.0%)	64,900	21,433	7,513	28,947	35,953
TOTAL:	264,854	56,733	29,253	85,986	178,868

				OVERHEAD ANTICIPATED:	72,399
			SPENDING BALANCE AVAILABLE AS OF 7/16/91:		106,469

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Expenditures:

The accompanying table shows the figures for expenditures to date, including amounts committed but not actually spent.

Overall Status and Plans:

Our original proposal focused on three research activities: Increasing the sophistication of plan projection; devising a formal semantics for plans; and applying task-oriented vision techniques to planned object acquisition. An important goal was to port agent-planning techniques to real robots to see how they fared. We are still strongly committed to that goal. We will be studying planning techniques for both robot arms and mobile robots. We are acquiring a Zebra-0 arm, and will be coordinating with Prof. David Kriegman of the EE Department on the use of his mobile robot, to avoid unnecessary duplication of effort. At this point, the object-acquisition work will probably involve only the robot arm, while the mobile robot will be used to study map learning and use.

We envisioned having several graduate students working on this project. There are currently three: Michael Beetz, Michael Black, and Sean Engelson. Black and Engelson are covered by outside fellowships for most of their funding. We will be recruiting more students in the coming year, but we may also attempt to hire a postdoc to take up some of the slack.